WATER LEVEL TANK USING FUZZY LOGIC CONTROLLER

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A report submitted in partial fulfilment of the requirement for the degree of Electrical Engineering in Mechatronic with Honour

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" I declare that this report entitle " Water Level Tank using Fuzzy Logic Controller" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

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Date : 23/06/2016

" I hereby declare that I have read through this report entitle " Water Level Tank using Fuzzy Logic Controller" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Mechatronic) with Honour"

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Date : 23/6/2016

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ABSTRACT

Water Level Control is the most important element in the process control. Application of a controller is widely used in industries especially for mould and die casting process and also for the level monitoring of water in reservoirs. The most controller used in industries is PID Controller, but the system is poor effected when the parameter in not chosen nicely. On the other hand, by using Fuzzy Logic Controller, the control performances are increase in time response and overshoot percentage. In order to get the accuracy on level changes, a simple work project water level sensor and water level controller based on Fuzzy Logic is proposed. The hardware of the project is based on the suitable and simplicity of the tank shape. The tanks used in the project were seal with water proof liquid to avoid the water from flowing out. The experiment is conduct to find the resistance value in order to complete the transfer function of the selection model of the tank. The Fuzzy Logic Controller is select as the controller to control the system for accuracy of level in the tank. The technique use in this project is based on Takagi-Sugeno Method which are the typically in the case of constant output. This method is selected due to the types of motor pump that acting as actuator in the tank. All the range values at the membership function and the rules table are decided based on the different of error and rate of change in the tanks. The testing on the parameter level is consists of the microcontroller with and without the fuzzy controller. At the end of the experiment, the differences between the two experiments are shown. After implemented the controller into the system, the time response had shown an improvement compared with non-controller adaption into the system. The time response had shown the improvement from 8.74 second to 0.2667 sec for rise time. Meanwhile for settling time improved from 24.2 second to 6.980 second. The overshoot percentages from 4.32% to 0% with time peak 18 second to 7 second. The result is shown illustrated in sequences.

ABSTRAK

Proses Pengawalan Air adalah sebuah proses yang amat penting didalam sesebuah sistem. Proses in banyak digunakan secara meluas didalam industi terutamanya pada proses pembentukan acuan plastik atau besi dan proses kawalan terhadap empangan sungai atau air. Pengunaan kawalan yang dinamakan "*PID Controller*", amat meluas didalam sistem pemgawalan paras cecair. Akan tetapi, pengawal ini akan mendatangkan kesan yang buruk kepada sesebuah sistem sekiranya unsur-unsur yang terdapat pada pengawalan tersebut tidak ikuti atau dipilih secara tepat. "*Fuzzy Logic Controller*" adalah salah satu pengawal yang boleh digunakan didalam sistem proses pengawalan paras air. Pengawal ini memberikan impak yang positif pada sistem dari segi kecepatan masa bertindak dan ketepatan paras air yang telah ditetapkan. Didalam mencari ketepatan pada setiap perubahan air, "*Fuzzy Logic Controller*" akan digunakan sebagai Pengawal di dalam projek ini. Bentuk Perkakasan yang digunakan didalam projek ini adalah bentuk segi empat kerana ianya sesuai dan mudah. Kedua-dua tangka yang sama saiz digunakan dalam projek ini haruslah ditampal dengan bahan kalis air bagi mengelakkan berlakunya kebocoran. Terdapat beberapa ujikaji yang dilakukan didalam projek ini, seperti ujikaji untuk mencari pemodelan matematik terhadap tangki ini. "*Fuzzy Logic Controller*" adalah pengawal yang dipilih untuk dimasukkan kedalam sistem bagi pengawal paras air keluar dan masuk. Teknik yang digunakan didalam "*Fuzzy Logic*" adalah teknik "*Tagaki-Sugeno*". Teknik ini dipilih kerana nilai yang keluar pada motor pam adalah nilai yang tidak boleh dimalarkan. Setiap jarak yang ditentukan didalam setiap keahlian dan peraturan adalah berdasarkan kepada perbezaan nilai ralat dan nilai perbezaan perubahan air pada tangki tersebut. Setelah pengawal ini dimasukan kedalam sistem, ujikaji terhadap perubahan air dilakukan. Diakhir ujikaji ini menunjukkan perbezaan diantara sistem tanpa pengawal dan sistem yang menggunakan pengawal "*Fuzzy Logic*" Data yang diperoleh menunjukan peningkatan terhadap masa peningkat dari 8.74 saat kepada 0.2667 saat, dan masa perubahan meningkat dari 24.2 saat kepada 6.980 saat Nilai peratus dalam setiap ketinggian data meningkat dari 4.32% kepada 0% pada masa 18 saat kepada 7 saat. Setiap data digambarkan melalui graf yang disusun.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The control system is a basic principle of logical and natural operations. Maintain the temperature, level and fluid flow rate in the system are the examples of the natural operation in the process of the control system. The addition of new technologies in the control system by replacing the human function came with the term of "Automatic Control" in the control action. The basic principle in Process-Control is to regulate the value of the quantity. By regards the dominants elements, the value of the quantity can be managed at the reference value or set point value. Adjust the Level of Liquid is the most similar example of system control that using the process-control principle.

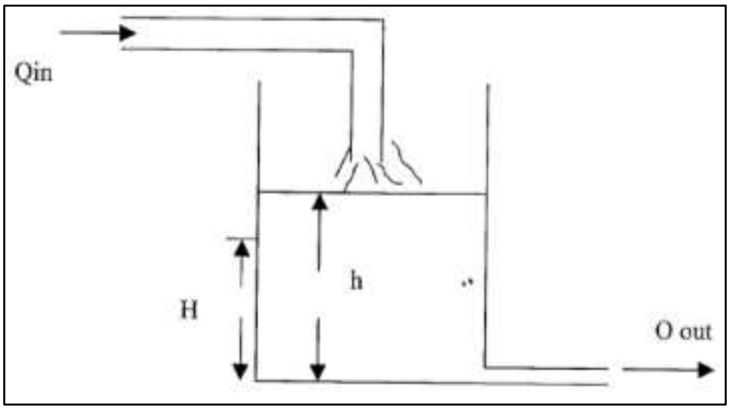

Figure 1.1: The level of liquid in the tank

Figure 1.1 shows the process of self-regulation system. The liquid is flowing along the pipe to the tank until it reaches the height (h) in which output of flow rate (Q out) is equal to the input rate (Q in). If both rates are in an unbalanced condition, the water level will drop or rise from the reference set point. In this process, shows the system does not provide any variable regulation to the reference value.

The technology of artificial control was developed over the past decades by used humans as the controller action to the system. This system called as Human-Aided Control. The level of the water tank can be indicated by using sight tube Figure 1.2 to compare the level of the water (h). On the other hand, the flow rate of the output can be manipulated by adjusting the valve in order to change the water level using a human control. If the measured value is larger than the set point, the human opens the valve to a minimum in order to give the water filled into the tank until it reaches the set point H. This situation also happened when the water is smaller than the set point. The user acts as indicator to monitor the water level at the S tube.

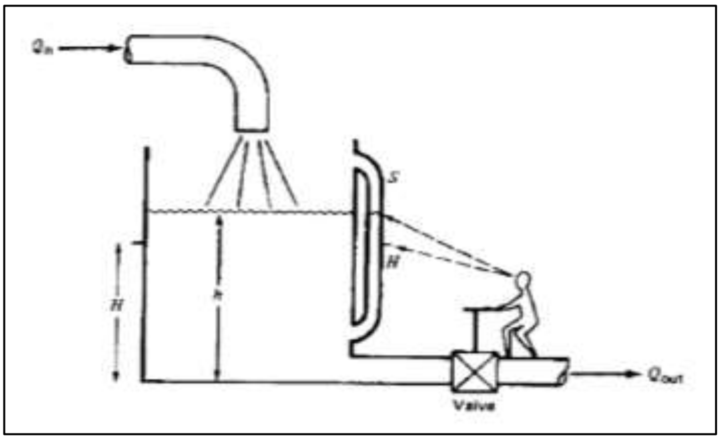

Figure 1.2: A human can regulate the level a sight tube S to compare the level h, to compare the desired set point level, H and adjust a valve to change the level

Automatic Control is the altered system by using machines, electronics and computers to change the human operation. By referring to the Figure 1.3, the sensor act as the indicator added into the system in order to monitor the change of the level of the water in the tank. The output signal from the sensor is converted into the proportional signal (s) and it became the input for the controller. The controller performs the function of the human in evaluating the measurement and providing the output signal (u) to operate the valve via an actuator. The mechanical linkage is connected to the actuator in order to control the valve [1].

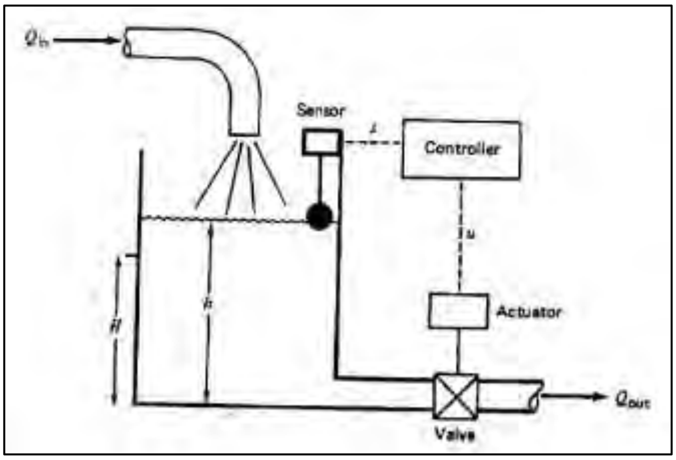

Figure 1.3: Automatic Level control system replaces the human with the controller and sensor to detect the level

1.2 Motivation

Over the past decades, the research on computer control of manufacturing system has been extending as it requires a deep understanding on how to implement the complete system. The application of liquid level control has been detected in tank level gauging of milk, level gauging of acid, oil and level monitoring of water in the reservoir. Many industrial worldwide needs the process of liquid level control in order to improve the capabilities and efficiency of the production. [2]

For instances, water treatment plants are used by the industries to the kept the plants in a good and safe condition without any infection that caused by the excess water. That proves the water level controlling system is an important process that have to be managed some parameter values for the smooth running process in order to get the quality product. The process is possible upon controlling the level of water in the tank system. [3]

1.3 Problem Statement

The liquid level control system is used to manipulate the change of water level parameter in the tank. Nowadays, there are many technologies production industrial process need to control and maintain the liquid level with inaccurate values given. Mostly, in the industries, the Conventional PID Controller is used to indicate the level of the liquid in the tank system. The PID controller is used because of their reliable, simple and accurate in the closed loop feedback system. However, if the parameter of PID controller is not chosen nicely, it might have the poor effect to the system. On the other hand, by using Fuzzy Logic controller, the overshoot of the system is limited in order to have a great control performance.

1.4 Objectives

The Aim of this project is:

I. To design and tune the Fuzzy Logic Controller in Water level Tank System

II. Analysis the result of the Fuzzy Logic Controller performance (overshoot and the transient response) of the Water Tank System

1.5 Scope

The scope of this project based on the two tanks that connect in a series position. The hardware of this project is only available at Underwater Lab, FKE UTEM because of the physical size of the tank. The size of the both tanks are same with 25 (L) x 25 (W) x 45 (H) in centimetre. The limitation of the project is based on the height filled by water which is maximum at 30 cm and the constructed of tanks materials is glass. The tanks are fragile and easy-to-broke. Besides that, this project only focuses on the transient response and the overshoot percentages that produced by Fuzzy Logic Controller in this system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter discuss the controller selection based on the 5 Conference Paper from IEEE sites. Controller Analysis based on the control performance that obtained from the graph and the complexity of the architecture to build the project. The control performance has to be included the transient response time, the overshoot percentage and the steady-state error of the system. The better control performance shows are decided the summarization of the controller selection analysis

2.2 Controller Selection Analysis

2.2.1 Journal 1: "Research on Application of Fuzzy PID Controller in Two - container Water Tank System Control" – Yan Zhao, 2010 [4]

This Journal Paper describe the designing the Fuzzy PID Controller in the liquid level system. The structure of the water tank is shown in Figure 2.1 below. The researcher goals are to find the strong robustness, favourable dynamic response, fast rise time and small overshoot percentages system in order to achieve the accuracy of the water tank. In this system, the mathematical equation of two serial volume tanks is produced to get the final kinematic equation of water level. In this paper also, describe the three (3) method that been too satisfied the goals. The first method is used is step interference method. In this method the researcher want to measure the dynamics response characteristic of the level object of water tank liquid.by using this method, the result is observed on level change value with corresponding time by using "time amplitude recorder". The end of the data presented in transfer functions and draw technically by graphical technique. The graph is gradually increased curve with time constant against the changes of the water level. The second method used to design the adoption of Fuzzy PID Controller. By using this method, the end result came with 4 elements namely: Basic Domain of exposition, the Fuzzy domain of exposition, Fuzzy Set and the Quantization Factor. In order to make a fuzzy output inference synthesis of this design the method of weighted mean is implemented. The result of the liquid level control system of two container water is processing using Matlab Simulation Software. The graph is shown in Figure 2.2. The graph shows the satisfied achievement in over modulation quantity and steady state error performance.

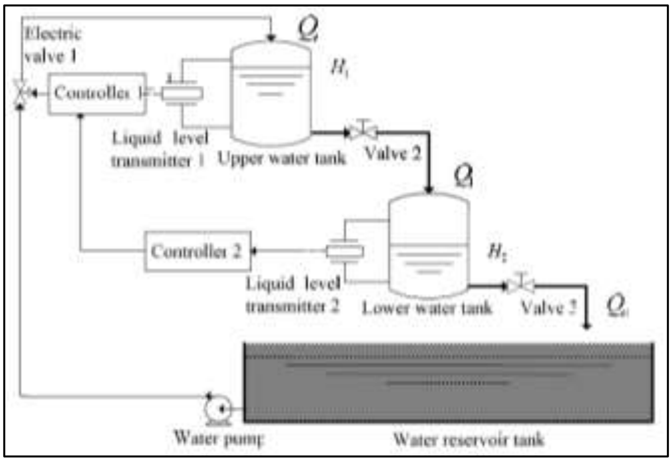

Figure 2.1: Structure chart of two-container water tank liquid level control system

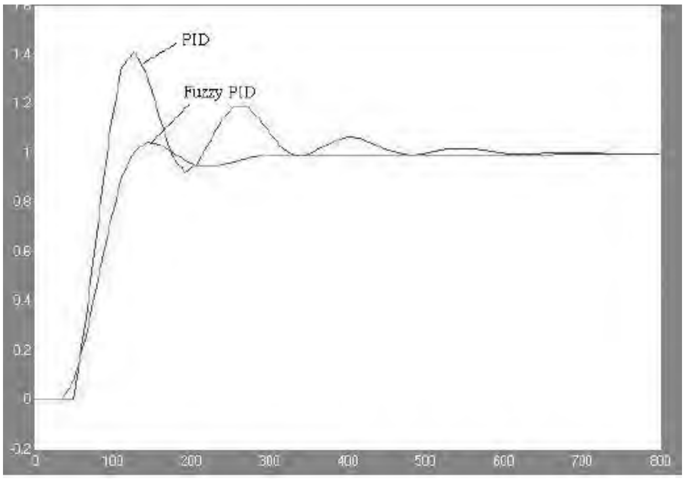

Figure 2.2: Comparisons between simulation result of PID control and Fuzzy PID control

2.2.2 Journal 2: "Fuzzy Adaptive PID Control Tank Level" – Qianhua Xiao, Deqiong Zou and Ping Wei, 2010 [5]

In this conference paper, introduce the Fuzzy Logic Controller to control the unpredictable output of the water tank. The researcher states that using the Fuzzy Algorithm method and Fuzzy Adaptive PID Control method, the result can control the system up to 0.00008 squares of error in order to achieve the accurate and precise control. This Conference paper also describes the methods that are used to design the Fuzzy Logic Control of this system. In this system, the transfer function is rearranged from the first inertia principle of the single tank as shown in Figure 2.3 below. The most important method that the researcher used in designing the Fuzzy PID Adaptive control is the knowledge of experience to tune the three parameters, namely: proportion coefficient, integral coefficient and integral coefficient. In order to adjust the Fuzzy control, it must have the suitable Fuzzy Rule Table. The seven fuzzy set is the most established to control this system. The end of the result, the researcher presented the graph of actual level compare with expected level graph as shown in Figure 2.4. The analysis by using Simulink of plotting the comparison graph, the goal of this system is satisfied to achieve the accuracy and precisely up to 99.84% of error range 0.0013. The result is achievable to control the system of the liquid level in the tank.

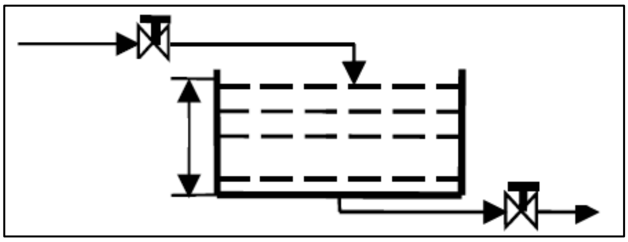

Figure 2.3 Structure of single tank

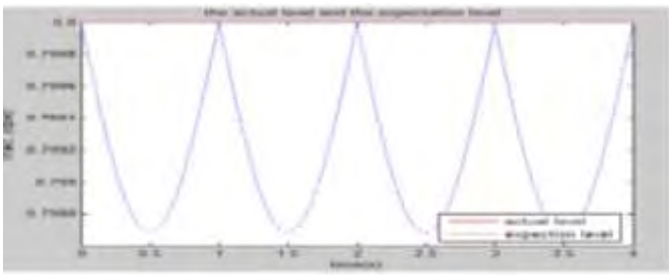

Figure 2.4 the actual level and the expectation level

2.2.3 Journal 3: "Level Control System of Double-hold Water Tank Based on Inverse System Method and PID" – Hu Likun , Li Guangping and Huang Wenqin , 2010 [6]

This Journal Paper discusses the combination method of the inverse system with PID controller in order to achieve the double-hold water tank control. The method of this system started with the determination of the model parameter. The structure of the modelling is shown in Figure 2.5 below. The output flow and the level are measured by using linear fitting and average method. After that, the inverse system method based on Iterator Algorithm is used to eliminate and simplified the equation of the mathematical model double-hold water tank. Next, in order to get the simulation of the Pseudo-Linear system graph, the inverse system must be connected with the tank in series form. The linearization and de-linearization graph is presented in Figure 2.6 below. This graph also proves that the inverse system is available to design the PID Controller. Since the graph is approved, the inverse system is lead to the close-loop transfer function of the water tank equation. The result of the transfer function is presented by plotting the graph on bode plot. The result shown the output signal of the inverse system is sent to the input of the actuator after the amplitude limiter reacted. As the conclusion, after done some adjustment time, the steady state error is reducing until less than 5%. Other than that, the system shows the fast response after the set value of level is changing. Figure 2.8 show the effect of using Conventional PID control method in this system.

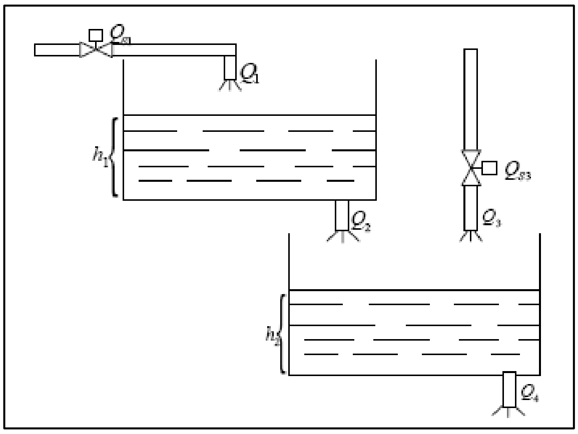

Figure 2.5 the structure model of the double-hold water tank